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ADMIRALTY FLEET ORDER

TURBINE GLANDS—FITTING OF CARBON RINGS

ADMIRALTY, S.W.1,
8th July, 1943.

The following Order having been approved by My Lords Commissioners of the Admiralty is hereby promulgated for information and guidance and necessary action.

By Command of their Lordships,

H. V. Markham

To all Commanders-in-Chief, Flag Officers, Senior Naval Officers, Captains and Commanding Officers of H.M. Ships and Vessels, Superintendents or Officers in Charge of H.M. Naval Establishments, and Admiralty Overseers concerned.

NOTE:—The scale of distribution is shown in the Admiralty Fleet Order Volume, 1941, Instructions, paragraph 10.

Head of "P" Branch

3122.—Turbine Glands—Fitting of Carbon Rings

(D. 14666/42.—8 Jul. 1943.)

The adverse effect of small steam leaks on the habitability of machinery spaces has become increasingly evident during hostilities and this has served to accentuate the difficulties that are sometimes associated with the upkeep of carbon glands. The following information, incorporating the results of extensive experience with carbon glands of all designs (including "L" type), is accordingly issued for guidance, as reports indicate that the correct methods of refitting and maintaining glands of this type may not be widely appreciated:—

(1) Satisfactory operation of properly designed carbon glands for reasonably extended periods can only be obtained by meticulous observance of correct procedure in fitting and by avoiding subsequent corrosion of the spindles.

(2) *Fit of carbon rings.*—The carbon rings should be fitted to form a smooth unbroken annulus, the internal diameter of which approximates closely to the external diameter of the spindle when both items are at their working temperature.

This requirement can best be met by fitting each carbon ring so that its internal diameter, when cold and with the segments butting, exceeds that of the spindle by an amount sufficient to accommodate the relatively larger expansion of the spindle under steam.

The alternative method of fitting the segments, so that there is a clearance at the butts when cold, is to be avoided; the differential expansion of the carbons and the spindle causes this clearance to increase as the gland heats up, so providing a leakage path for the steam: also the pressure of the segments on the spindle accelerates the wear of both these parts, especially in the presence of corrosion products.

It should be realised that the segments are subjected to a radial load, comprising a relatively light component of the garter-spring tension and a much heavier one due to the steam pressure acting on the periphery of the ring: the latter may be excessive at the inner rings of "all-carbon" glands, possibly causing distortion of the spindle if the segments are allowed to bear thereon. The spindle can only be relieved of this pressure by ensuring that the segments butt under all conditions.

(3) *Diametrical clearances.*—Figure 1 of A.F.O. Diagram No. 207/43 (1) in conjunction with the following table, gives the correct cold clearance for carbon gland rings fitted in main and auxiliary turbines of H.M. ships.

Type of Turbine and gland	Working temperature to be taken for reading clearance from Fig. 1
H.P. turbines*	250° F.**
L.P. turbines	150° F.**
Turbo generators and other self-condensing auxiliaries—	
H.P. end	250° F.**
L.P. end	150° F.**
Auxiliary turbines exhausting to auxiliary exhaust system	250° F.**

* In the case of H.P. turbine glands of the all-carbon type the temperature quoted should be taken for the outer ring and for each successive inner ring add 25° F. to the temperature. In all cases work to the nearest 0.001-in. from the figure read from Figure 1.

** These figures do not represent the actual temperature of the relevant glands but are chosen to give reasonably satisfactory adjustments over the whole working range of turbines fitted in current British naval practice. Experience will indicate whether modifications are desirable in individual cases.

(4) *Axial clearances.*—It should be realised that the carbon ring must provide a seal, not only on the rotating shaft, but also on the low pressure

side of the housing against which it is pressed by the steam pressure ("A", Figure 2), and consequently both these latter mating surfaces must not only be flat, but also truly at right angles to the shaft axis.

The normal figure for the axial clearance of the ring in the housing is about 0.015-in., less than this may prevent freedom of action and result in excessive wear, but up to 0.030-in. may be provided with cast iron housings where the risk of rusting is greater. Generally speaking it will be found that the spare rings are the correct thickness in this respect.

(5) *Stop pins.*—The stop pins should have clearance to allow for radial movement of the ring, but, subject to this provision, clearances should be kept as small as practicable, particularly if they provide a leakage path for the steam.

(6) *Fit of housing.*—Other possible sources of leakage are between the housing and turbine casing, and along the joint between the two halves of the housing. The radial faces of the housing must be true and at right angles to the shaft, when the box is jointed in place. These points should be carefully checked and corrected as necessary. The use of thick jointing material is very undesirable, as this may lead to malalignment of the housing in relation to the shaft axis.

(7) *Corrosion of spindles and drainage arrangements.*—One of the chief causes of troubles with carbon glands, particularly with auxiliary machinery, is corrosion and roughening of the shaft due to inadequate drainage, especially when the turbine is standing. This collection of water may be prevented by applying a vacuum to the turbine for a period after all steam has been shut off, but in modern auxiliaries the shaft (or its sleeve where so fitted) in the way of the carbon gland is usually chromium plated to prevent corrosion. Corrosion of spindles occurs in two localities:—

(i) *Under the carbon rings.*—Water will tend to collect between ring and spindle at this point.

(ii) *Between the carbon rings.*—This can be prevented by proper drainage of gland housing. The drain holes must be of adequate size, and must be located to give as complete drainage as possible, with due regard to the inclination of the turbine axis.

Each ring compartment should have a drain of not less than $\frac{1}{8}$ in. diameter; it should always be checked that these are clear and that the gland is assembled so that they are at the lowest point in the compartment.

(8) *Mandrels.*—In all new construction mandrels, as shown in Figure 3 of A.F.O. Diagram No. 207/43 (2) are provided, their diameter being larger than the shaft diameter by the amount necessary to provide the correct cold clearance. The spare rings supplied are ground to this size, but they should be checked on the mandrels prior to fitting.

If a mandrel has not been provided one should be made, the necessary cold clearance being estimated as described above, if not given in the maker's instructions. Where a shaft has been reground to a smaller size, than the original diameter, a new mandrel should be made to suit the correct cold clearance for the new shaft diameter and the old mandrel it replaces scrapped. The collar of the mandrel should be truly machined at 90°, and the corner slightly recessed as in Figure 3, to allow the segment to mate fully on the bore and side face at the same time. On each mandrel should be stamped its diameter to the nearest thousandth and the name of the glands and shaft diameter for which it is suitable.

Each mandrel should be carefully greased and protected with a brass sleeve when not in use.

(9) *Fitting of new rings.*—The manufacturers supply rings exactly to the bore specified, which generally corresponds to the diameter of the shaft plus the cold clearance recommended. The rings are accurately manufactured to fine limits, the sides and joints are dead square and segments are interchangeable without affecting the accuracy of the ring. No filing or scraping should be necessary, unless the rings are required for a shaft diameter other than that for which they were supplied.

The following method of fitting is recommended:—

- (a) Confirm that the mandrel is suitable for the particular spindle—see paragraph 1 (3). In the case of an all-carbon gland of an H.P. turbine, the diameter of the mandrel should be such that a ring fitted to it will give the correct cold clearance on the shaft for an outer ring. The inner rings should have a diametrical clearance on this mandrel, sufficient to provide the additional cold clearance on the shaft recommended in the footnote to the table in paragraph 1 (3). For example the inner ring of a six-ring H.P. turbine gland for a shaft 8.000-in. in diameter should have a diametrical clearance of 0.004-in. on a mandrel of diameter 8.006-in.
- (b) If after trying the ring on the mandrel some fitting is found to be necessary each individual segment of the packing must be separately faced and scraped to fit the mandrel, using the machined surface of the mandrel as a guide (lower part of Figure 3). Fierce and rough scraping must be avoided, as the bearing surface of each segment must be quite smooth. Rough axial markings on the bore and radial markings on the side faces are particularly to be avoided, as these would give open paths to steam leakage.
- (c) A complete ring should then be assembled with its spring on the mandrel for fitting the butts, with each segment mating at the same time on the two surfaces of the mandrel. Each joint should be truly butted, so that a 0.0015-in. feeler cannot be inserted at any edge. Bad joints such as shown in Figures 5, 6 and 7 must be corrected and a fit as indicated by Figure 2 should be aimed at.

The segments supplied by the makers are completely interchangeable and the order or way in which they are assembled to form a ring is of no importance. If, however, it is necessary to remove any material from the segments where they butt, in order to fit to a slightly smaller shaft, it is important that the joints in each ring be marked, so that the segments of each ring can be arranged on the shaft in the order in which they were fitted on the mandrel.

(10) *Assembling rings on the shaft.*—(a) When mounting the rings on the turbine shaft check that, with all the segment joints butted and flush at the bore, the clearance between shaft and ring is as estimated in accordance with paragraph 1 (3).

(b) Where the position of the stop preventing rotation of the ring permits of this, the joints of consecutive rings in the housing should be staggered, as in the case of the rings on a piston.

(c) See that the axial clearance for each segment is sufficient to prevent sticking—see paragraph 1 (4).

(d) If a helical garter spring is employed be careful not to overstretch it in mounting the ring. When in position the spring should not be more than about one tenth longer than its free length if of steel, or one twentieth if of monel metal.

(e) In certain designs, with large diameter carbon rings, a flat spring is fitted in the bottom of the housing, to take the weight of the ring off the shaft. In such cases it should be checked that this spring is neither too strong nor adjusted so that it would result in abnormal pressure between the carbon ring and the bottom of the shaft at the working temperature. If there is any doubt about this it is better to omit the spring, since even large rings are comparatively light.

(f) Figure 8 shows the design of side pressure ring, employed in some glands, where the pressure drop across the ring is insufficient to seal the ring and housing faces at A. The garter spring bears simultaneously on the sloping side of the carbon at B and on the wall of the housing at C, and so exerts an independent axial thrust keeping the ring and housing in contact at A.

In such cases it should be checked that, when the ring and spring are assembled in the housing, the spring bears on the housing at C and not on the

ring at D. It may be possible to check this by assembling the ring and spring in the housing without the shaft, when the friction at A should be sufficient to support the weight of the ring within the confines of the housing. It is important that the ring and spring are fitted so that axial thrust exerted by the latter on the former is in the same direction as that of the steam pressure.

(11) *Fitting in an emergency without a mandrel.*—A mandrel should if possible always be used, but when shafts are badly worn or have been stoned to different diameters, this may not be practicable. In such circumstances the general requirements should be complied with, as far as is practicable, by the use of feelers and a square. It is however much more difficult to get an accurate fit with this method.

(12) *Running-in of new rings.*—The operating temperatures of the shaft in way of each ring cannot be accurately measured, and the "cold" ring clearances estimated in accordance with paragraph 1 (3) may therefore be either slightly too small or slightly too large.

(a) *Carbon clearances too small.*—This will be indicated by either of two conditions:—

(i) Turbine vibrates. Vibrations get worse if temperature and speed are not reduced.

(ii) Shaft overheats and shows temper colours, which it may not be possible to see under running conditions. In these circumstances speed must be reduced, and if conditions do not improve the turbine must be stopped. Examine the rings, which will show a mirror finish either continuous or in spots, these bright surfaces should be carefully erased.

If clearances are only slightly too small the rings can be "run-in" as follows in turbines (usually auxiliary units only) where this procedure is applicable.

Operate the turbine for, say, one hour at each of a series of gradually increasing speeds. If vibration occurs or discolouration of the shaft is seen reduce speed immediately. Raise and lower the speed several times slowly.

Operate again at the speed where vibration originally occurred. In most cases the trouble will have been overcome. If the foregoing procedure does not eliminate vibration or overheating, the packing must be dismantled and refitted, at the same time making certain that the vibration does not arise from other causes.

(b) *Carbon clearances too large.*—The packing will not be steam tight at full speed and at maximum temperature.

To correct this, remove some carbon with a very smooth and fine file (or fine emery cloth) from one surface of each butt joint. Do not remove more than about $\frac{1}{1000}$ -in. per joint even if gland is leaking badly.

Thoroughly clean the rings and the joint faces of the gland box before re-assembly.

Test again under steam and if necessary repeat the foregoing process.

It must be appreciated that naval turbines are required to operate with steam at widely varying temperatures, and that in general if the diametrical cold clearance is correct for maximum working temperature it must, due to the different rate of expansion of carbon and steel, be slightly greater than is necessary at lower working temperatures; it may be necessary therefore to accept slight leakage under this condition.

(13) *Unusual Cases.*—If persistent leakage occurs at a gland that has been fitted in general accordance with the foregoing, as a first action the details of the adjustments should be meticulously checked over; if no evident cause is thus revealed, attention should be directed to the following:—

- (i) Clearances around the pins or other devices for preventing rotation of the carbons. These in some design are possible sources of leakage and the clearances must be made as fine as possible; it has been found for instance that, if the clearance round a $\frac{3}{16}$ -in. diameter pin passing right through a carbon greatly exceeds about $\frac{3}{1000}$ -in. the resulting steam leakage will be unacceptable—see paragraph 1 (5).

- (ii) Axial clearances of rings in their pockets must be adequate, to permit freedom of ring to accommodate small radial movements of the spindle due to slight out of balance—see paragraph 1 (4). If a carbon ring jams in its pocket, any subsequent vibration of the spindle may cause serious damage.
- (iii) Make sure that the leakage is not between turbine casing and gland housing—see paragraph 1 (6).
- (iv) Differential expansion, or thrust of steam and exhaust connections on the turbine casing, may cause distortion of the gland housings, so that the bearing surfaces for the rings are not perpendicular to the shaft under working conditions. A small increase in axial clearances of rings in their boxes may be of service in such cases. In one instance it was found beneficial to turn the gland housing so that the joint between its two halves was no longer in the same radial plane as the horizontal joint between turbine casings.

2. In conclusion it should be emphasized to all concerned that time and care spent in ensuring proper fitting will be more than compensated by long life and good performance of the packings.

3. Additional copies of this order may be obtained from the Editor of Fleet Orders, c/o H.M. Stationery Office Press, Wealdstone, Harrow.

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